Modeling bomb radiocarbon in the post-bomb era

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Many bomb radiocarbon studies have assumed that nuclear-weapons era variation in atmospheric radiocarbon content or $\Delta^{14}C$ would have been negligible in the absence of atmospheric nuclear detonations, and that changing atmospheric ^{12}C content has negligible effect on the air-sea transfer of ^{14}C. These assumptions were reasonable for simulations of GEOSECS observations. However, to simulate more recent WOCE data at the 10% level of accuracy, a more complete treatment of the carbon system may be necessary.

Several factors, related to fossil fuel burning and deforestation, are redistributing natural ^{14}C among the atmosphere, ocean and biosphere. As pointed out by Seuss, Keeling and others, the global distribution of radiocarbon is affected by (i) ^{14}C degassing from the ocean induced by enhanced surface ocean total dissolved inorganic carbon concentrations, (ii) diminished ^{14}C absorption by the terrestrial biosphere due to uptake by plants of CO_2 with lower $^{14}C/^{12}C$ ratios, (iii) ^{14}C released during deforestation, and (iv) non-linear interactions among these factors.

We force models of the atmosphere, ocean and terrestrial biosphere with estimated fossil fuel fluxes, deforestation fluxes and atmospheric $^{12}CO_2$ concentration to estimate what atmospheric ^{14}C content, and $\Delta^{14}C$, would have been without nuclear explosions. We find that about one-fourth of the increase in atmospheric $^{14}CO_2$ from mid-1945 to the present is due to the factors listed above, with the remaining three-fourths due to nuclear weapons detonations.

Furthermore, enhanced surfaced ocean ΣCO_2 slows oceanic absorption of bomb radiocarbon. A 25% increase in atmospheric CO_2 content slows the uptake of bomb radiocarbon by ~10%. Also, marine biogeochemiphysical processes transport about 10% of the bomb ^{14}C to the deep ocean. Accuracy at the 10% level requires modeling of marine biogeochemiphysical processes.

We used our ocean biogeochemistry model coupled to our version of GFDL's Bryan-Cox model to estimate the magnitude and geographic distribution of $^{14}CO_2$ fluxes and inventory changes induced by anthropogenic $^{12}CO_2$ and bomb radiocarbon, taken individually. We compare these results with conventional perturbation approaches.

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